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TRANSLATION

INVESTIGATION OF NON-METALLIC MATERIALS FOR SLIDING BEARINGS SUITABLE FOR CERTAIN CONDITIONS OF FRICTION IN CHEMICAL MACHINE CONSTRUCTION

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INVESTIGATION OF NON-METALLIC MATERIALS FOR SLIDING BEARINGS SUITABLE FOR CERTAIN CONDITIONS OF FRICTION IN CHEMICAL MACHINE CONSTRUCTION

I. V. Vasil'yev

In chemical machine construction there occur mechanisms in which the moving couplings of parts operate directly in chemically active liquid media. The selection of materials for these parts is very difficult since the chemically active medium on the friction surface sharply change the antifriction properties of the materials.

With joint action of the force of friction and the chemically-active medium on the friction surface of the metal there is a special kind of wear which in technical literature is called corrosion-mechanical [1]. The antifriction materials which are used for sliding bearings and seals in most cases cannot be used in the presence of a chemically active medium.

The following is a report on the results of tests on the durability of materials for sliding bearings operating in a 1% NaOH solution and a 15% H_2SO_4 solution.

Tests were carried out on an Kh2M laboratory friction machine according to the method suggested by Khrushchov and Babichev [2] as

well as on an MT-2 friction machine built by the Scientific-Research Institute of Chemical Machinery (MIIKhIMMASh) according to the method developed there.

The Kh2M friction machine uses a system of rubbing a hole on the surface of the sample with a disk. Figure 1 shows an over-all view of the Kh2M machine. The thickness of the disk is 3 mm and the diameter 50 mm. The sliding surface of the disks is refined to class 9 [standard deviation of surface irregularities 0.2 to 0.4 μ]. Spindle rotation is constant and equal to 530 rpm.

Test results were determined by the volume of the rubbed hole V according to the formula

$$V = \frac{bl^3}{12r},$$

where b = disk width, mm;
r = disk radius, mm;
l = hole length, mm.

The samples measured 10 × 10 × 40 mm with the surface refined to class 9.

A Brinell loupe was used for measuring the hole wear. Wear-resistance was tested in a 1% NaOH solution and in a 15% H_2SO_4 solution. The samples were degreased before testing.

The following conditions were selected for testing of samples in a 1% NaOH solution: disc of R18 steel, hardness Rc = 62 to 64; disks of steel 45; iron SCh 18-36, steel Kh23N27M2T, textolite 2B and fluoroplast-4 were also used for testing the wear-resistance of fluoroplast-4; temperature of the liquid medium equalled 25 to 80°; samples were of steel-20, steel-45, iron SCh 18-36, bronze BrKMTs, graphite PK-O, fluoroplast-4 and textolite 2B; the load on the samples in each tests was 5, 10, and 15 kg; the tests interval under each load was 8 minutes.

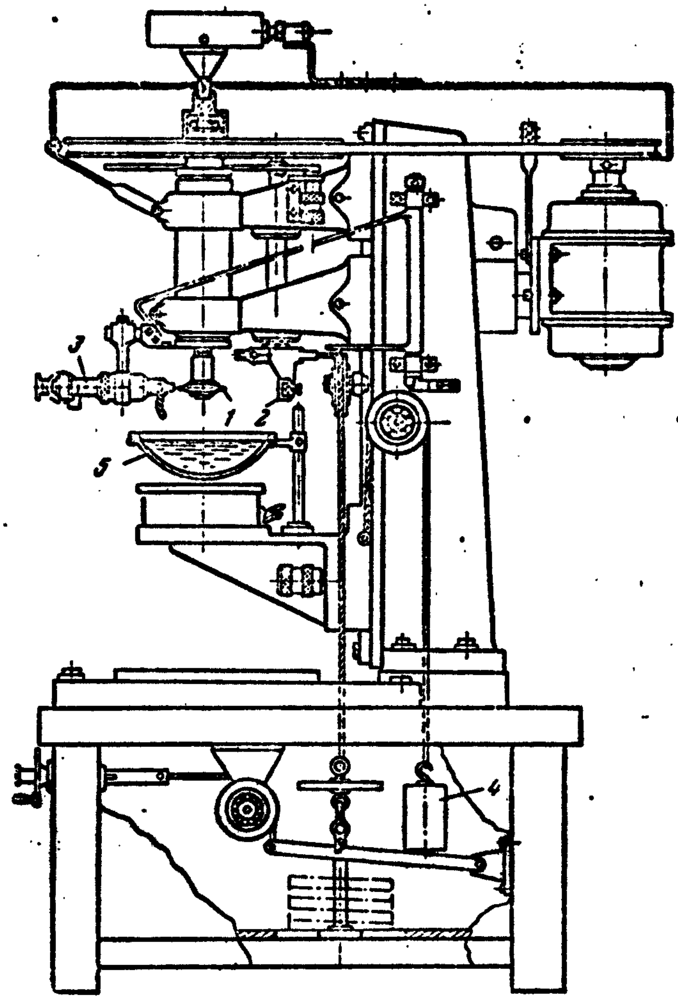


Fig. 1. Diagram of Kh2M machine
1) disk; 2) test sample; 3) Brinell loupe; 4) load; 5) bath

The test conditions for samples in a 15% H_2SO_4 solution were as follows: disk of steel Kh23N27M2T; temperature of the liquid medium 25°; samples of graphite-ye, graphite-ye impregnated with lead, graphite PK-0, fluoroplast-4 and textolite 2B; the load in all tests was constant and equal to 3kg; each test lasted 5 and 30 minutes.

The MT-2 machine (Fig. 2) is similar in operation to the "R" machine of M. M. Krushchov. On the MT-2 friction force was measured with a balance. The test samples (bearing bushing and journal) were submerged in a bath with a medium whose temperature was maintained by an electric heater. The machine is designed to allow for replacement of the bushing and journal. Two bushings with a diameter of 50 mm and length of 50 mm were tested simultaneously. Wear on the bushing is determined either from the loss of weight (for a 1% NaOH solution) or from the difference in dimensions of the bushing measured with an indicating micrometer before and after testing (for a 15% H_2SO_4 solution.) Journal wear was not determined. The drive mechanism of the MT-2 is continuously variable from 0 to 1000 rpm.

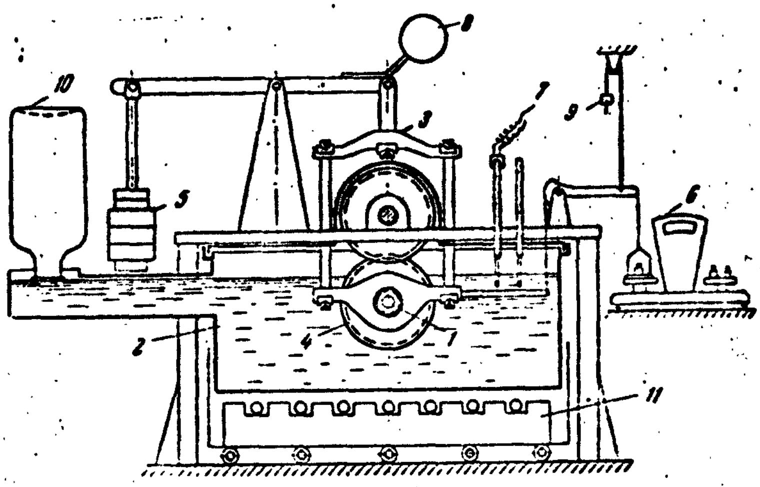


Fig. 2. MT-2 friction machine.

1) test bearing; 2) medium; 3) parallelogram for measuring friction force; 4) drive wheel for transmitting rotation; 5) load; 6) balance for measuring friction force; 7) thermostat; 8) load-arm counterweight; 9) counterweight for lever to measure friction force; 10) container for maintaining solution level; 11) electric heater.

Some of the materials tested on the Kh2M were also tested on the MT-2; the material of the disk corresponded to that of the journal,

while the material of the sample corresponded to that of the bushing. The unit load P on the MT-2 was constant and equal to 5 kg/cm^2 while the sliding rate was 15 m/min in the case of 1% NaOH and 60 m/min for 15% H_2SO_4.

Results of Testing Materials for Wear in a 1% NaOH Solution

Tests on the Kh2M Friction Machine

Figure 3 shows the dependence of volumetric wear on load for various materials at a solution temperature of 25°. It may be noted that for given test conditions a direct proportionality between volumetric wear of the material and the load is observed. The wear rate of fluoroplast-4 is five times lower than for steel-20 and seven times lower than for graphite-PK-0..

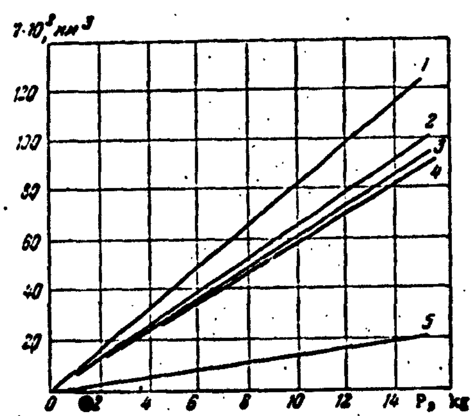


Fig. 3. Dependence of volumetric wear on load when testing on the Kh2M in 1% NaOH at 25° for an 8-min test period.

1) graphite PK-0; 2) steel 20; 3) iron SCh-18-36; 4) bronze BrKMTs; 5) fluoroplast-4.

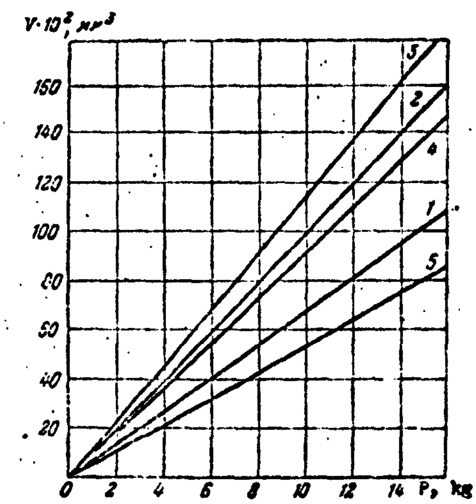


Fig. 4. Dependence of volumetric wear on load when testing on the Kh2M in 1% NaOH at 80°C for an 8-min test period.

1) graphite PK-0; 2) steel 20; 3) iron SCh-18-36; 4) bronze BrKMTs; 5) fluoroplast-4.

Figure 4 shows the dependence of volumetric wear on load for a temperature of 80° C.

It is apparent from a comparison of the graphs (Figs. 3 and 4) that increasing the temperature of the medium sharply increases the wear of all materials with the exception of graphite PK-0.

Table 1 shows the change in material wear rate with temperature.

TABLE 1

Influence of temperature of medium on the magnitude of volumetric wear of materials.

Material	Volumetric wear v, $mm^3 \cdot 10^2$, at a temperature of	
	25° C	80°C
Fluoroplast-4	5,83	21,90
Bronze BrKMTs	27,00	46,60
Iron SCh 18-36	32,76	57,06
Steel 20	32,76	54,80
Graphite PK-0	42,87	35,90

It can be seen from Table 1 that the wear rate of fluoroplast-4 is 3.5 times greater at 80° than 25°. It must be noted that although the chemical properties of fluoroplast remain unaltered up to a temperature of 300°, its mechanical properties change sharply with an increase in temperature [4] which apparently has an effect on its durability.

Tests have indicated that the durability of fluoroplast-4 depends not only on the temperature of the medium but also on the material of the disk.

The dependence of volumetric wear V of fluoroplast-4 on the material of the disk is characterized by the following data:

	v, $mm^3 \cdot 10^2$
Steel P18	5.4
Steel 45	10.7
Iron SCh 18-36	26.8
Textolite	41.0
Steel Kh23N27M2T	68.0
Fluoroplast-4	86.0

Testing of Materials for Sliding Bearings on the MT-2 Friction Machine

The journals and bushings were prepared with an accuracy of A_3 and Kh_3. Before wear testing, the combined parts (samples) were run in for a period of two hours with gradual loading.

Since the test data for all materials are presented in the literature [3], we will consider here only the results for fluoroplast-4. Fluoroplast-4 bushings were tested with a journal of steel 45 for a period of 32 hours with a unit load ρ of 5 kg/cm^2 at solution temperatures of 25 and 80° C. The weight loss of the bushing at 80° proved to be 3.5 times greater than at 25°, i.e., it increased by approximately the same amount as on the Kh2M machine. Thus, the dependence of wear resistence of fluoroplast-4 on solution temperature is verified.

Comparing data on the wear of fluoroplast-4 bushings with those of bushings of iron SChTs-2 as well as bronze BrAZhN 10-4 and 5-4 (given in Ref. [3]), it may be noted that the wear-resistance of fluoroplast-4 bushings is significantly greater than for bushings of other materials, i.e., the conclusion concerning the wear-resistance of fluoroplast-4 obtained on the Kh2M machine is verified. Data on the wear-resistance of fluoroplast-4 with respect to the material of the disk as obtained on the Kh2M friction machine are verified by the data obtained on the MT-2. The relationship between the wear-resistance of fluoroplast-4 and journals of textolite and fluoroplast-4 as obtained on the Kh2M was also verified by test results on the MT-2.

The force of friction was measured throughout the test. Table 2 shows average values of the coefficient of friction for several

test materials under a unit load of 5 kg/cm^2 and sliding rate of 15 m/min in 1% NaOH at 80° C. The friction force was measured after running-in.

The tests which were conducted confirmed a high wear-resistance for fluoroplast-4 when operating with a journal of steel 45. The wear-resistance of a fluoroplast-4 bushing was determined from six months of continuous operation. It should be noted that capron and nylon may be used successfully in a 1% NaOH solution.

TABLE 2

Average values of friction force

Material		Coefficient of Friction	
Journal	Bushing	at 25°C	at 80°C
Steel 45	Iron SChTs-2	0,5	0,47
"	Fluoroplast-4	0,078	0,038
Iron SChTs-2	Iron SChTs-2	0,18	0,048

Results of Material Wear in 15% H_2SO_4

Tests on the Kh2M Friction Machine

The tests were conducted under a constant load of 3 kg for a period of 30 minutes with paired disks of Kh23N27M2T.

The results of the wear tests are characterized by the following data:

	v, $mm^3 \cdot 10^2$
Textolite 2B	21
Graphite PK-O	35
Fluoroplast-4	140
Graphite Ye with lead	155
Graphite Ye	202

It is apparent from these data that textolite 2B and Graphite PK-O are the most wear-resistant.

Tests of Sliding Bearing Materials on the MT-2 Machine

The journal was prepared from steel Kh23N27M2T and the bushings for the bearings from graphite Ye, Graphite Ye impregnated with lead, graphites D and PK-O (nonimpregnated and impregnated with resin), and textolite 2B. Solution temperatures were 25 and 75% C. The test results are given in Table 3.

TABLE 3

Results of tests on the wear of bearings of various materials with friction against a journal of steel Kh23N27M2T in 15% H_2SO_4 carried out on the MT-2.

Bearing Material	Duration of test, hours		Radial bearing wear, mm		Character of journal friction surface
	25°C	75°C	25°C	75°C	
Graphite Ye	15	90	2,1	2,6	Grooves
Graphite Ye impregnated with lead	30	—	2,4	—	"
Textolite 2B	—	590	—	0,25	Grooves "pitting"
Graphite D	—	260	—	1,3	Polished surface
Graphite PK-O	—	162	—	1,1	"
Graphite PK-O impregnated with resin	—	250	—	0,32	"

It is apparent from Table 3 that graphites D and PK-O exhibit the best wear-resistance; these data correspond to those obtained on the Kh2M friction machine with respect to wear-resistance.

Testing of the friction surface is very important in the study of the nature of corrosion-mechanical wear. The external appearance of the friction surface may to some degree characterize the wear-resistance of the material. Such in investigation of the friction

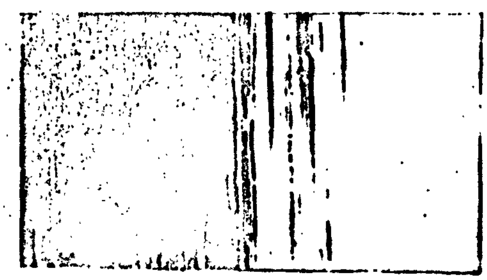
surface was made with the MIM-7 microscope (×150).

Two portions were photographed at the same time: the friction surface of the journal and the section of the journal not contacting the bushing. Comparison of these surfaces made it possible to evaluate the changes which take place on the journal under friction. Comparison of the surface of the journal before and after friction against graphite Ye showed that after 90 hours of testing annular grooves and ridges appeared on the surface and roughness was increased to class 6 [standard deviation of surface irregularity greater than 1.6 to 3.2 μ]. Similar grooves indicating severe wear of graphite Ye also appeared on the bushing. The bath was greatly contaminated with the products of wearing. The origin of annular grooves on the friction surface of the journal is apparently explained by hard impurities contained in the graphite Ye.

The same friction-surface characteristic was observed on a journal tested with textolite 2B for a period of 590 hours. Not only course deep annular grooves but also corroded sections were visible on the journal. Figure 5 shows a microphotograph of the friction surface on which course annular ridges and polished sections are visible. Despite the fact that wear on the textite 2B bushing during this same time was less than 0.25 mm, this combination of materials cannot be recommended since the wear-resistance of the journal is clearly unsatisfactory.

Fig. 5. Microphotograph of the friction surface of a journal of steel Kh23N27M2T after 590 test hours at 75°C in combination with textolite 2B (×150).

The best results were obtained when testing a journal with a bushing of graphite PK-0 impregnated with resin (see Table 3). It is apparent from a microphotograph of this journal after 250 hours of testing (Fig. 6) that the friction surface is polished to a luster and that there are no grooves or scratches on it. There were no products of wear from the graphite in the bath during the test. A similar journal surface was also observed when testing bushings of graphite D and PK-0 not impregnated with resin. Judging from contamination of the bath, the process of polishing took place for graphite D and PK-0 not impregnated with resin in a period of 50 hours. For graphite PK-0 impregnated with resin this process proceeded much more rapidly in the same period of time. The polishing effect which shows up on the journal apparently depends on the abrasive properties of the bushing, on the ability of the bushing to remove the protective film from the metal, and on the rate of its formation. When there is a partial removal of the protective film which forms on steel, local regions affected by corrosion occur on the friction surface of the journal; the roughness of the surface increases and this leads to an increase in the rate of wear of the bushing material.



a b

Fig. 6. Microphotograph of the friction surface of a journal of steel Kh23N27M2T after 250 hours of testing in combination with graphite PK-0 impregnated with resin.

a) free section; b) friction surface of the journal (x150).

The coefficient of friction as a function of sliding rate and unit load was measured on an MT-2 friction machine.

The coefficient of friction was determined on run-in samples. The lowest value was obtained for a bushing of graphite PK-0 impregnated with resin (Figs. 7 and 8).

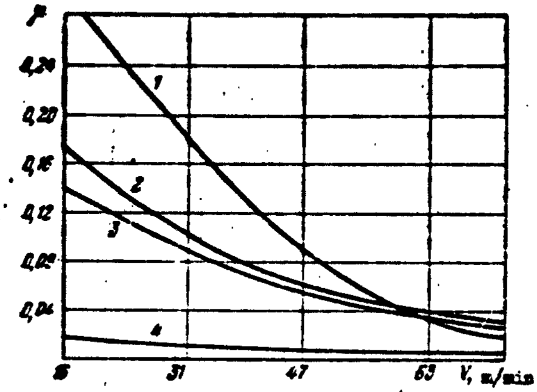


Fig. 7. Dependence of coefficient of friction μ on sliding rate.

1) textolite 2B; 2) graphite D; 3) graphite PK-O; 4) graphite PK-O (impregnated with phenol-formaldehyde resin).

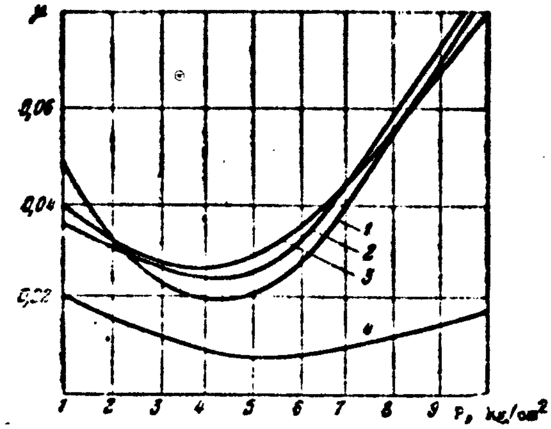


Fig. 8. Dependence of coefficient of friction μ on unit load.

1) textolite 2B; 2) graphite D; 3) graphite PK-O; 4) graphite PK-O (impregnated with phenol-formaldehyde resin).

The mechanism of polishing of the journal (as a result of the abrasive action of the graphite) is probably analogous to the effect of electo-polishing, in spite of the fact that a 15% H_2SO_4 solution cannot under static conditions serve as an electrolite for the electro-polishing of stainless steel Kh23N27M2T.

Conclusions

1. The reliability of operation of antifriction plastics under friction in aggressive media depends not only on their chemical stability but also on the corrosion resistance of the metals opposing them.

2. On the basis of tests made at the NIIKhIMMASH, fluoroplast-4 may be recommended as a material for sliding-bearing bushings operating in an alkaline medium. Taking into account the fact that the temperature of the alkaline medium has a great effect on the wear-

resistence of fluoroplast-4, it is recommended that fluoroplast-4 be used at noncritical points of friction and for cases where a hydrodynamic friction regime is guaranteed.

Graphite PK-0 or D impregnated with resin is recommended for operation in a 15% sulfuric acid solution. When selecting material for the journal it is necessary to take into consideration its corrosion resistance.

3. It is recommended that tests of materials for wear-resistance exposed to a corrosion-mechanical form of wear be carried out on the Kh2M laboratory friction machine according to the method suggested by M. M. Khrushchov and M. A. Babichev and on the MT-2 machine constructed by the NIIKhIMMASh.

Tests carried out at the NIIKhIMMASh indicated a correspondence of results obtained on the Kh2M and MT-2 friction machines for the wear-resistance of materials.

REFERENCES

1. M. M. Khrushchov. Klassifikatsiya usloviy i vidov iznashivaniya. Sb. "Treniye i iznos v mashinakh", VIII, 1950.

2. M. M. Khrushchov and M. A. Babichev. Metodika ispytaniy metallov na iznashivaniye pri treniy v prisutstviy zhidkoy sredy. Sb. "Treniye i iznos v mashinakh", X, 1955.

3. I. V. Vasil'ev and A. D. Gopius. Korroziya i iznos metallov. Sb. "Issledovaniye antifriktsionnykh svoystv materialov dlya podshipnikov skol'zheniya, rabotayushchikh v shchelochnoy srede", NIIKhIMMASh, No. 27.

4. I. V. Vasil'yev. Korroziya i izonos konstriktsionnykh materialov khimicheskogo mashinistroyeniya. Sb. "Issledovaniye protsessa iznashivaniya i zayedaniy materialov pri treniy v shchelochnoy srede", NIIKhIMMASh, No. 25.

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